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Comparison of transversus abdominus plane block with two different doses of levobupivacaine for postoperative pain management in pediatric patients

Emel Uyar, Sanem Çakar Turhan, Menekşe Özçelik, Neslihan Alkış

Department of Anesthesiology and Reanimation, Faculty of Medicine, Ankara University, Ankara, Turkiye

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Corresponding Author: Emel Uyar, emeluyar27@hotmail.com

ABSTRACT

Aims: Transversus abdominus plane (TAP) block is a simple, effective and reliable method in postoperative pain management following lower abdominal procedures. The aim of the current study is to investigate the effects of two different doses of Levobupivacaine in TAP block for postoperative management and to evaluate whether we can achieve effective pain management with lower dose than the recommended dose of Levobupivacaine.

Methods: Fifty patients aged between 2-12, undergoing unilateral inguinal surgery were included to the current randomized, controlled study. The patients were randomized to group C (control) (TAP block with Levobupivacaine 0.25%, 0.5 ml/kg) and group LD (low dose) (TAP block with Levobupivacaine 0.25%, 0.25 ml/kg). Following monitorization and achieving sufficient anaesthesia depth, ultrasound (USG) guided TAP block was performed to all patients. The pain intensity [visual analogue scale, observer pain scale and faces scale], recovery profile (Modified Aldrete Recovery Score) and patient satisfaction were evaluated postoperatively. Peripheral nerve block complications and side effects were recorded during postoperative period.

Results: No significant difference was found between groups demographic data ($p>0.05$). There was no significant difference between groups in terms of VAS, OPS, faces scale, patient satisfaction ($p>0.05$). The number of patients requiring rescue analgesic was 12 patients in control group and 14 in low dose group ($p>0.05$). No complication and side effects were observed.

Conclusion: TAP block with low dose Levobupivacaine may be successful to manage pain with less toxicity, and reduces complications due to local anesthetics.

Keywords: Levobupivacaine, TAP block, pediatric patients

INTRODUCTION

Postoperative pain in the pediatric age group may cause discomfort, hemodynamic status impairment, and organ dysfunction. Postoperative pain control is very important in order for children to have a more peaceful recovery after surgery with fewer complications. In addition, postoperative pain is one of the most significant causes of morbidity in patients undergoing surgery.[1]

The method used to evaluate pain in children should be selected based on important considerations such as age, general status, and level of pain recognition, and should be repeated at certain intervals. Factors such as developmental level, family attitudes, effects of inpatient hospital care, symbolic meaning of pain, and physiological response to pain can all be used to evaluate pain in children. It is difficult to distinguish between hunger, pain, and fear as causes of crying and anxiety in young children. The effectiveness of pain treatment in surgical practice and modern pediatric anesthesia is therefore assessed based on numerous physiological responses to stress.[2-4] It is not always possible to assess pain in infants or in children with cognitive or physical disorders. In these cases, observational evaluation of behaviors and biological methods can be used as alternative tools. QUESTT is the standard approach for the evaluation of pain in children.[2]

Q–Question the child

U–Use pain rating scales

E–Evaluate child's behavior

S–Secure parent's involvement

T–Take cause of pain into account

T–Take earliest action

The transversus abdominis plane (TAP) block is one of the abdominal field blocks used for the treatment of acute postoperative pain after lower abdominal surgical procedures. First described by Rafi[5] TAP block is a procedure in which local anesthetic agents are administered to the neurofascial gap between the internal oblique and the transversus abdominis muscles located in the anterolateral region of the abdominal wall, in order to block the lower thoracic and upper lumbar nerves. The analgesic efficacy of TAP block has been demonstrated with several studies.[6] TAP block is a procedure that local anesthetic agents are given to anatomic neurofascial gap between the internal oblique and transversus abdominis muscles located in the anterolateral region of abdominal wall to block anterior branches of thoracic intercostal (T7-T12) and first lumbar (L1) nerves. While TAP block application is performed with resistance loss technique by using Petit's triangle, a part of the procedure is performed with USG.[7-11] Sharma and co-workers[12] noted that TAP block provides effective long-lasting analgesia for patients undergoing abdominal surgery. Ultrasound-guided (USG) TAP block provides effective analgesia in the postoperative period and allows the high level of analgesic distribution to the nerves under the muscle fasciae.[5]

The innervation of inguinal region (skin, muscles, and parietal peritoneum) is mediated by the anterior branches of the spinal nerves between T7 and L1. The intercostal nerves (T9-T11), subcostal nerves (T12), ilioinguinal (L1) and iliohypogastric nerves (T12-L1) are located in the area between the internal oblique muscle and the transversus abdominis muscles which is called the "TAP". The block is performed to anaesthetize the neurofascial area, which is an anatomically empty space. The needle should be placed slightly directed toward the cranial just above the external part of the iliac crest where the lateral part of the latissimus dorsi muscle inserts, behind the midaxillary line. The needle then passes through the internal oblique muscle and the fascia. A second "click" is felt when passing the fascia. After careful aspiration, the appropriate volume of local anesthetic agent is injected. When the technique is performed with USG, the needle tip can be advanced to the TAP more safely and accurately. USG technique provides visualization of the three abdominal muscles at the lateral point of the rectus abdominal muscle, allowing for different injection points appropriate for varied surgical procedures. Selective blocks of the ilioinguinal and the iliohypogastric nerves are possible with USG, as in a cadaver study, and the three different muscle layers (external, internal oblique, and transversus abdominis) are visible across the aponeurotic area at the lateral abdominal wall. If local anesthetic is administered to the fascial layer, the distribution may be seen. It is defined as the TAP. We conducted a study to evaluate the effectiveness of the USG guided TAP block, using two concentrations of levobupivacaine for postoperative pain control in pediatric patients who undergoing unilateral inguinal surgery.

METHODS

This randomized, controlled, single-center, prospective, phase 4 clinical trial was conducted in the Department of Pediatric Surgery at Ankara University in 2015. A total of 50 pediatric patients between the ages of 2 and 12 years (American Society of Anesthesiologists (ASA) health status 1-2 levels) scheduled for unilateral inguinal hernia surgery were included in this study. The Turkish Health Ministry and Turkey Medical Medicines and Medical Devices Authority approved the study (Date: 30.05.2015, Decision No: 93189304-514-04-01) and consent forms were obtained from all patients before the surgery. Patients with skin infections near the incision site, coagulation problems, allergies to any of the analgesic agents used in the study, and chronic cardiac-renal and hepatic insufficiencies were excluded from the study. All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki. Patients were randomly divided into two treatment groups by closed envelope method.

All fifty patients underwent unilateral inguinal surgery. The patients randomized to group C (control) received the TAP block with 0.5 ml/kg Levobupivacaine 0.25%. The patients in group LD (low dose) received the TAP block with 0.25 ml/kg Levobupivacaine 0.25%. The age and weight of patients were recorded.

Routine monitoring (ECG, non-invasive arterial blood pressure, arterial oxygen saturation) of the patients was performed in the operating room, and the data were recorded as preoperative control data.

A peripheral venous line with an appropriately sized intravenous catheter was opened for cooperative patients. 1% propofol 2 mg/kg (propofol-lipuro 1%, B. Braun, Melsungen, Germany) was administered by intravenous line. For non-cooperative patients, induction was performed by first administering 8% sevoflurane (Sevorane® Liquid %100, Queenborough, England) and 50% nitrous oxide and 50% oxygen combination by facial mask, and then 1% propofol 2 mg/kg was administered by intravenous line. Laryngeal mask was placed following induction. Anaesthesia management was provided by 2 % sevoflurane with a combination of 50 % nitrous oxide and 50 % oxygen. Intravenous fluid maintenance was provided with a sodium chloride 0.3% and glucose 3.3% infusion at a rate of 10 ml/kg/h.

Preoperative preparations were performed according to the postoperative regional analgesia technique to be performed. TAP block dosage was calculated for all patients according to assigned study group and weight.

The lateral abdominal wall of the patients (in supine position) was sterilized with povidone-iodine. For all procedures, the practitioner was on the same side as the procedure side. A 10-18 MHz linear USG probe coated with a sterile sheath was placed transversely between the costal margin and the iliac crest on the same side of the abdominal wall. When necessary, the USG probe was directed to the cephalic-caudal, the anterior-posterior direction, or the angle needed to visualize the three lateral abdominal muscles clearly, and the initial image was optimized. Once the external oblique, internal oblique, and transversus abdominis muscles were clearly visualized, a 50 mm, 20-gauge needle (B.Braun Stimuplex, Melsungen, Germany) was inserted and advanced from the anterior surface of the USG probe by in plane technique. After visualization of needle placement in the TAP with

USG, levobupivacaine 0.25% was injected at a concentration of 0.5ml/kg for patients in group C and at a concentration of 0.25 ml/kg for patients in group LD. Once the distribution of the anesthetic agent was observed in the TAP, the needle was removed, and surgery was allowed to proceed. After the surgical procedure, administration of anesthetic gasses was discontinued and patients were ventilated with 100% oxygen until oxygen saturation values reached 97% and above and patients had spontaneous breathing. The type of surgery, duration of surgery, intraoperative hemodynamic parameters were recorded. The time of completion of surgery was recorded as t=0 and patients were followed at specific intervals: 10 min, 20 min, 30 min, 60 min, 6h, and 24h. During this period, all of the patients were evaluated using the modified aldrete recovery scores. Patients with a postoperative score of 7 or above were taken to the recovery room. Pain levels were evaluated using the Observer Pain Scale, Visual Analog Scale (VAS), Faces scala and data were recorded. Observer pain scala and face scala used for all of the patients. VAS used for patients who above 4 years. A designated researchers assessed pain with a four-graded observer scale (no pain, mild pain, moderate pain, severe pain). The child with reported pain by using a six-graded faces scale. In every patient, the result of the four-graded scale was recorded before the evaluation with the faces scale. Children asleep were considered not to be in pain. The first analgesic request time, total analgesic consumption, and any adverse effects such as nausea or vomiting were recorded. Supplementary analgesia was to be provided when the observer considered the child to be in moderate or severe pain or the child recorded pain scores of 3, greater on the faces pain scale or VAS score was 4 or above. Paracetamol 15 mg/kg was administered as supplementary analgesia. After paracetamol administration, ibuprofen 10 mg/kg was given to patients who had still pain.

Statistical Analysis

The data analysis of the data obtained in the study was performed using SPSS for Windows v. 15.0 (IBM Corp, NY). Numerical values were expressed as mean±SD or median (interquartile range). The student's t-test was used to compare the normal distribution of the numerical data with the Shapiro-Wilkes test followed by the normal distribution and the result was evaluated according to the equality of variances. The Mann-Whitney U test was used to compare non-normal numerical data. Categorical data were given as numbers. Pearson's Chi-square test and Fisher's exact test were used for comparison of categorical data. The Wilcoxon test was used for intra-group comparison. $p<0.05$ was considered significant.

RESULTS

For both groups, there was no statistically significant difference in gender, weight, age, or duration of surgery.

When intraoperative heart rate was evaluated (at 1, 3, 5, 10, 15, 20, 30 and 40 min), there was no statistically significant difference between groups. Heart rate values at 5, 10, 15 and 20 min. were significantly lower in the C group than at 1 min ($p<0.05$). The heart rate value at 15 min. was found to be significantly lower in the LD group than at 1 min ($p<0.05$) (**Figure 1**). There was no significant difference between groups in terms of average arterial blood pressure (**Figure 2**). There was no significant difference between groups in terms of recovery score (**Figure 3**). There was no statistical difference between groups in terms of the Observer Pain Scale (**Figure 4**). There was no statistical difference between groups in terms of the Faces Scale.

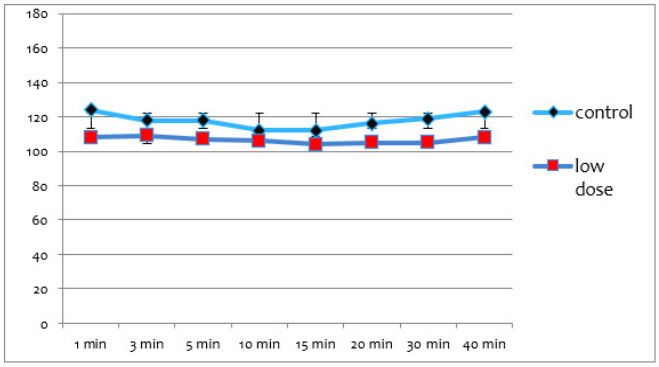

Figure 1. Heart rates

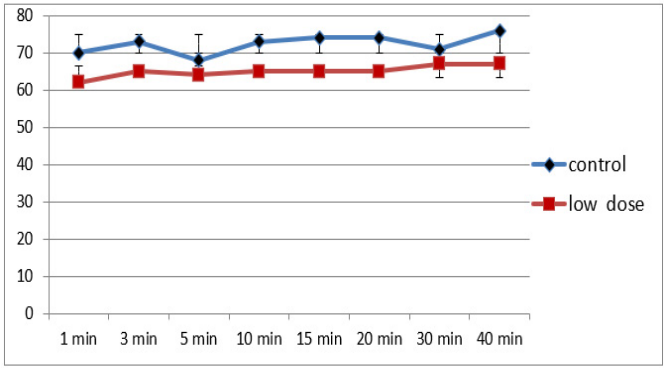

Figure 2. Average arterial blood pressure

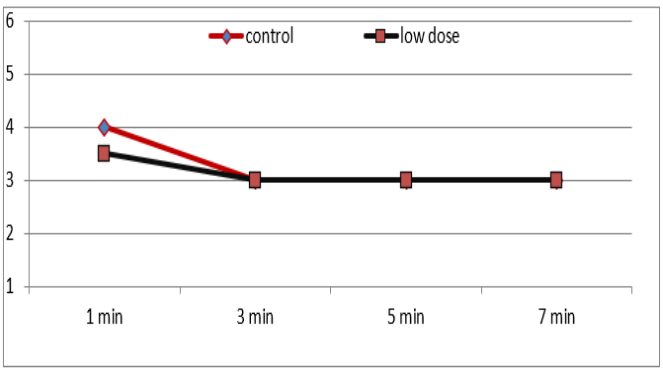

Figure 3. Modified Aldrete Recovery Score

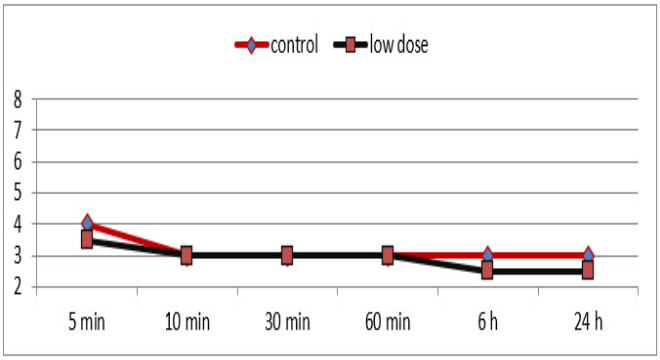

Figure 4. Observer Pain Scale

Fifty patients were included in our study (C group: 25, LD group: 25). No postoperative analgesic was required for 13 patients in the C group and 11 patients in LD group. At t=30 min post-surgery. There were 12 patients requiring postoperative analgesic in the C group, compared to 14 in the LD group. There was no statistically significant difference between groups in terms of analgesic requirement or patient satisfaction. There were no complications reported related to the procedure.

DISCUSSION

Recently, the number of block applications performed in pediatric patients has increased, because the use of USG increases the possibility of success and reduces the risk of complications. Based on our results, we think that TAP block with low dose levobupivacaine may be successful for managing pain with less toxicity, and may reduce complications due to local anesthetic. We aimed to control the postoperative pain in pediatric patients with TAP block application with low dose levobupivacaine. According to Taddio and co-workers[13] neonates having pain experience had different behaviors according to their pediatric ages, so they found that the main purpose of pain control was to prevent pain instead of reducing the pain. Therefore, pain management in pediatric patients is very important. The negative effects and complications of pain include decreased respiratory movements and coughing limitations. This situation may cause atelectasis and pulmonary complications. Severe pain may cause cardiac arrhythmia, hypertension, and myocardial ischemia. Immobility and prolongation of hospital stay may increase the likelihood of thromboembolic complications.[14-16] Findlow and co-workers[17] found that ilioinguinal/iliohypogastric nerve block with bupivacaine was more effective than caudal block. We preferred levobupivacaine because of lower cardiotoxicity. In a randomized controlled trial, Carley and co- workers[18] cited that TAP block reduced postoperative opioid consumption, and also that VAS scores was found to be lower in the TAP group (both at rest and motion). We thought that TAP block with USG guidance was safer based on a previous study so we conducted our study with USG guidance. The local anesthetic dose should be adjusted to the child's age, weight, physical condition, and operation area.[19]

Takashi et al.[20] used TAP block for 40 patients undergoing gynecologic procedures and found that local anesthetics might reach toxic blood concentration levels and sometimes cause systemic toxicity. Therefore, they recommended reducing local anesthetic doses for TAP block to minimize the risk of toxicity. But this study was conducted in adult patients. Therefore, we also reduced the dose for pediatric patients who were more vulnerable to toxicity. For blockage, Jacobs and co-workers[21] used different levobupivacaine doses for 5 neonates and 5 babies.

They administered 0.25% levobupivacaine 1 ml/kg for unilateral blockage and 0.25% levobupivacaine 0.5 ml/kg for bilateral blockage, and found that the TAP block with levobupivacaine was effective in all patients. Also, they cited that a low dose of levobupivacaine might be used, and suggested further dose studies.[20,21] In our study, we used two different levobupivacaine doses and found that low dose efficacy was the same as normal dose efficacy.

Desgrandes and co-workers placed a subcostal TAP catheter in a 4-year-old patient undergoing upper abdominal surgery and provided successful pain management. Through this catheter, 0.25% levobupivacaine 0.5 ml/kg of was administered and then 0.25% levobupivacaine 1.5 ml/kg was given continuously by pump.[22] We preferred levobupivacaine as a local anesthetic agent and compared the success of TAP block application in two different doses in pediatric patients at the same concentration for postoperative pain control.

Sahin and co-workers[23] cited that TAP block provided long-lasting postoperative analgesia for unilateral inguinal hernia operations and reduced analgesia requirements to 0.5 ml/kg of 0.25% levobupivacaine diluted with 1/200000 adrenaline when compared to infiltration anaesthesia. Willschke and co-workers[24] cited that abdominal wall blocks with USG was a successful regional anaesthesia technique for providing postoperative analgesia. In our study, we used TAP block with USG to reduce complications and increase the success rate.

Suresh and co-workers compared two different levobupivacaine concentrations in pediatric patients undergoing inguinal hernia operations and found analgesia difference between the two doses, and less analgesia requirement in the high dose group 24 hours after the surgery. In our study, this is one of the important outcomings of our work.

Frederikson and co-workers[25] showed that the analgesic activity of USG TAP block using a 50:50 combination of 1% lidocaine 0.3 ml/kg and 1% ropivacaine diluted with 1/200000 epinephrine in 8 children. In another study of authors, they compared the analgesic activity of TAP block with USG to ilioinguinal block with USG[26] and found that recovery room pain scores, morphine consumption, ibuprofen usage, and satisfaction score were similar in both groups, but that clinical pain scores and ibuprofen usage were higher in the TAP group. We found that 0.5 ml/kg of 0.25 ml/kg doses of 0.25% levobupivacaine were effective for postoperative analgesia. Therefore, we think that low dose levobupivacaine might be suitable for postoperative pain management in pediatric patients at risk for toxicity with TAP block.

TAP block complications include bowel hematoma, liver laceration, and temporary nerve blockage.[27,28] The spleen and kidneys are other organs that may be injured during the procedure. A case report of a liver laceration in an adult patient has been reported due to TAP block. Farooq and Carey[27] reported liver lacerations in TAP blocks with the landmark technique. Lancaster and Chadwick[29] also reported liver laceration in TAP block with USG. We did not observe any complications due to TAP block.

Multiple analgesia methods may lead to more than one specific problem in the neonatal group of patients. With TAP block with USG, less local anesthetic agent was required and toxicity risk was reduced compared to infiltration method.[30,31] Fredrickson and co-workers[32] used TAP block in 4 newborns

undergoing abdominal surgery to provide pain management for the intraoperative and early postoperative period.

Vincent[33] reported that the optimal dose of levobupivacaine is not clearly established and is still empirical. At 0.4 mg/kg, none of the 1- to 5-year-old children presented toxicity signs, and there is evidence that this dose could be increased to obtain a better efficacy. And children's weight must be considered to evaluate their clearance and anticipate any risk of toxicity.

In children, quality of postoperative pain control provided by TAP block using levobupivacaine 0.4 mg·kg–1 administered as either HVLC or LVHC did not differ and was associated with a very low risk of local anesthetic systemic toxicity.[34]

CONCLUSION

We conclude that it is very important to use low-dose local anaesthesia in the pediatric age group, which is more at risk for local anesthetic toxicity. TAP block provides effective blockage with low dose analgesia. Ultrasound-guided TAP block with 0.25% levobupivacaine 0.25 ml/kg was found to be effective and reliable in pediatric patients. In conclusion, because toxicity is a significant consideration for the pediatric age group, we recommend TAP block for pediatric patients.

ETHICAL DECLARATIONS

Ethics Committee Approval

The Turkish Health Ministry and Turkey Medical Medicines and Medical Devices Authority approved the study (Date: 30.05.2015, Decision No: 93189304-514-04-01).

Informed Consent

Parents of all patients signed a free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

REFERENCES

1. Karslı B, Ertuğrul F. The postoperative analgesia procedures in children. *JARSS*. 2008;16(2):63-68.
2. Gehdoo RP. Postoperative pain management in paediatric patients. *Indian J Anaesth*. 2004;48(5):406-414.
3. Tüzüner F. Anaesthesia intensive care. 1st ed. Medikal&Nobel. 2010.
4. Kayhan ZE. Clinic Anaesthesia. 3rd ed. Logos. 2007.
5. Rafi AN. Abdominal field block: a new approach via the lumbar triangle. *Anaesthesi*. 2001;56: 1003-1029. doi:10.1111/j.1365-2044.2001.2279-40.x
6. McDonnell JG, Curley G, Carney J, et al. The analgesic efficacy of transversus abdominis plane block after cesarean delivery: a randomized controlled trial. *Anesth Analg*. 2008;106(1):186-191. doi:10.1213/01.ane.0000290294.64090.f3
7. O'Donnell BD, McDonnell JG, McShane AJ. The transversus abdominis plane (TAP) block in open retropubic prostatectomy. *Reg Anesth Pain Med*. 2006;31(1):91. doi:10.1016/j.rapm.2005.10.006
8. Bharti N, Kumar P, Bala I, Gupta V. The efficacy of a novel approach to transversus abdominis plane block for postoperative analgesia after colorectal surgery. *Anesth Analg*. 2011;112(6):1504-1508. doi:10.1213/ANE.0b013e3182159bf8
9. Ra YS, Kim CH, Lee GY, Han JI. The analgesic effect of the ultrasound-guided transverse abdominis plane block after laparoscopic cholecystectomy. *Korean J Anesthesiol*. 2010;58(4):362-368. doi:10.4097/kjae.2010.58.4.362
10. Milone M, Di Minno MN, Musella M, et al. Outpatient inguinal hernia repair under local anaesthesia: feasibility and efficacy of ultrasound-guided transversus abdominis plane block. *Hernia*. 2013;17(6):749-755. doi:10.1007/s10029-012-1022-2
11. Aveline C, Le Hetet H, Le Roux A, et al. Comparison between ultrasound-guided transversus abdominis plane and conventional ilioinguinal/iliohypogastric nerve blocks for day-case open inguinal hernia repair. *Br J Anaesth*. 2011;106(3):380-386. doi:10.1093/bja/aeq363
12. Sharma P, Chand T, Saxena A, et al. Evaluation of postoperative analgesic efficacy of transversus abdominis plane block after abdominal surgery: a comparative study *J Nat Sci Biol Med*. 2013;4(1):177-180. doi: 10.4103/0976-9668.107286
13. Taddio A, Katz J, Ilersich AL, Koren G. Effect of neonatal circumcision on pain response during subsequent routine vaccination. *Lancet*. 1997; 349(9052):599-603. doi:10.4103/0976-9668.107286
14. Dolin SJ, Cashman JN, Bland JM. Effectiveness of acute postoperative pain management: I. evidence from published data. *Br J Anaesth*. 2002; 89(3):409-423. doi:10.1093/bja/89.3.409
15. Ashburn MA, Caplan RA, Carr DB, et al. Practice guidelines for acute pain management in the perioperative setting. An updated report by the American Society of Anesthesiologists task force on acute pain management. *Anesthesiology*. 2004;100(6):1573-1581. doi:10.1097/00000542-200406000-00033
16. Guzeldemir ME. Postoperative pain management. *Bulletin of Gulhane Military Medical Academy*. 1996;38:273-277.
17. Findlow D, Aldridge LM, Doyle E. Comparison of caudal block using bupivacaine and ketamine with ilioinguinal nerve block for orchiopexy in children. *Anaesthesia*. 1997;52(111):1110-1113. doi:10.1111/j.1365-2044.1997.204-az0346.
18. Carney J, Finnerty O, Rauf J, Curley G, McDonnell JG, Laffey JG. Ipsilateral transversus abdominis plane block provides effective analgesia after appendectomy in children: a randomized controlled trial. *Anesth Analg*. 2010;111(4):998-1003. doi:10.1213/ANE.0b013e3181ee7bba
19. Polaner D, Suresh S, Cote CJ, et al. A practice of anesthesia for infants and children. *Pediatr Reg Anesth*. 2000:636-675.
20. Ishida T, Sakamoto A, Tanaka H, et al. Transversus abdominis plane block with 0,25% levobupivacaine. *J Anesthesiol*. 2015;29(4):557-561. doi:10.1007/s00540-015-1993-0
21. Jacobs A, Bergmans E, Arul GS, Thies KC. The transversus abdominis plane (TAP) block in neonates and infants - results of an audit. *Paediatr Anaesth*. 2011;21(10):1078-1080. doi:10.1111/j.1460-9592.2011.03628.x
22. Desgranges FP, De Queiroz M, Chassard D. Continuous oblique subcostal transversus abdominis plane block: an alternative for pain management after upper abdominal surgery in children. *Paediatr Anaesth*. 2011;21(9):982-983. doi:10.1111/j.1460-9592.2011.03582.x
23. Sahin L, Sahin M, Gul R, Isıkay N. Ultrasound-guided transversus abdominis plane block in children: a randomized comparison with wound infiltration. *Eur J Anesth*. 2013;30(7):409-414. doi:10.1097/EJA.0b013e32835d2fcb
24. Willschke H, Kettner S. Paediatric regional anaesthesia: abdominal wall blocks. *Paediatr Anaesth*. 2012;22(1):88-92. doi:10.1111/j.1460-9592.2011.03704
25. Fredrickson M, Seal P, Houghton J. Early experience with the transversus abdominis plane block in children. *Paediatr Anaesth*. 2008; 18(9):891-892. doi:10.1111/j.1460-9592.2008.02591.x
26. Fredrickson MJ, Paine C, Hamill J. Improved analgesia with the ilioinguinal block compared to the transversus abdominis plane block after pediatric inguinal surgery: a prospective randomized trial. *Paediatr Anaesth*. 2010;20(11):1022-1027. doi:10.1111/j.1460-9592.2010.03432.x

27. Farooq M, Carey M. A case of liver trauma with a blunt regional anesthesia needle while performing transversus abdominis plane block. *Reg Anesth Pain Med*. 2008;33(3):274-275. doi:10.1016/j.rapm.2007.11.009
28. Rosario DJ, Jacob S, Luntley J, Skinner PP, Raftery AT. Mechanism of femoral nerve palsy complicating percutaneous ilioinguinal field block. *Br J Anaesth*. 1997;78(3):314-316. doi:10.1093/bja/78.3.314
29. Lancaster P, Chadwick M. Liver trauma secondary to ultrasound-guided transversus abdominis plane block. *Br J Anaesth*. 2010;104(4):509-510. doi:10.1093/bja/aeq046
30. Weintraud M, Marhofer P, Bösenberg A, et al. Ilioinguinal/iliohypogastric blocks in children: where do we administer the local anesthetic without direct visualization? *Anesth Analg*. 2008;106(1):89-93. doi:10.1213/01.ane.0000287679.48530.5f
31. Jacobs A, Thies KC. Ultrasound-guided transversus abdominis plane block for reversal of ileostomy in a 2-kg premature neonate. *Paediatr Anaesth*. 2009;19(12):1237-1238. doi:10.1111/j.1460-9592.2009.03161.x
32. Fredrickson MJ, Seal P. Ultrasound-guided transversus abdominis plane block for neonatal abdominal surgery. *Anaesth Intensive Care*. 2009;37(3):469-472. doi:10.1177/0310057X0903700303
33. Vincent M, Mathieu O, Nolain P, Menacé C, Khier S. Population pharmacokinetics of levobupivacaine during transversus abdominis plane block in children. *Ther Drug Monit*. 2020;42(3):497-502. doi:10.1097/FTD.0000000000000702
34. El Sherif F, Gomaa Sayed D, Fares KM, et al. Magnesium sulfate in pediatric abdominal cancer surgery: safety and efficacy in ultrasound-guided transversus abdominis plane (US-TAP) block in conjugation with levobupivacaine. *Local Reg Anesth*. 2023;16:133-141. doi:10.2147/LRA.S425649